

Time matters: Why ecological effects of microplastics might change over time

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Abstract

Research Highlight: Lozano, Y. M., Gordillo, H., Waldmann, W., & Rillig, M. C. (2023). Photodegradation modifies microplastic effects on soil properties and plant performance. *Journal of Applied Ecology*, <https://doi.org/10.1111/1365-2664.14514>.

Plastics are omnipresent in daily life and so is plastic waste in the environment. Once there, plastic waste remains for a long time, slowly disintegrating into ever smaller particles including microplastics (particles <5 mm). Simultaneously, physical and chemical properties of these particles are modified due to aging processes. Although scientific awareness about microplastic effects on terrestrial ecosystems is recently increasing, current studies focused on the effects of pristine microplastics. However, modified properties due to aging could influence microplastic effects on terrestrial ecosystems and their components. In their current study, Lozano et al. provide first evidence that photodegradation can modify the effects of different microplastics on soil properties and plant performance, indicating that degradation could intensify microplastic effects on plant–soil systems. These results emphasise the need to better investigate how the global issue of plastic pollution affects ecosystems, also over the long term, and the need to stop the flow of plastics entering the environment.

KEYWORDS

ecotoxicology, microplastics, photodegradation, plant–soil interactions, plastic pollution

Plastics play a crucial role in modern society, being present in almost all areas of our daily life from food production to clothing to medicine and so forth; the list of applications is endless. As a consequence, vast amounts of plastics are produced, 390 million tons alone in 2021 (Plastics Europe, 2022). At the same time, as large proportions of plastics are not getting reused, recycled or disposed properly, ever increasing quantities of plastic waste are entering the environment (Geyer et al., 2017; Jambeck et al., 2015). Once there, plastic fragments slowly decay due to different factors, including mechanical forces or weathering (Figure 1), leading to the emergence of ever smaller particles, including microplastics (i.e. plastic particles <5 mm; Barnes et al., 2009). The problem of microplastic pollution first gained major attention in the context of marine biology (Cole

et al., 2011). However, as the majority of plastic waste is primarily ending up in terrestrial ecosystems (Jambeck et al., 2015), research focusing on effects of microplastics on terrestrial ecosystems is recently gaining momentum.

Looking at terrestrial ecosystems, the plant–soil system as a key component might be especially prone to microplastic effects as soils are a major sink for such plastic particles (Chia et al., 2021; Helmberger et al., 2020). Recent findings show that both soil properties and plant performance can be affected by microplastics (de Souza Machado et al., 2018; van Kleunen et al., 2020), as well as the way plants interact with soils (Speier & van Kleunen, 2023). On the other hand, such effects seem to be highly context dependent and could be influenced by, for example, the polymer type or particle



FIGURE 1 Plastic fragments of different sizes and shapes found in a natural grassland. In the environment, plastic waste is exposed to different factors promoting their decay, including photodegradation by UV radiation, potentially modifying the effects of microplastics on the plant–soil system. Note the clear signs of weathering and degradation.

shape and size (Lozano et al., 2021). Furthermore, current studies mainly focused on rather short-term effects. However, plastic fragments can remain in the environment for a long time during which their physical and chemical properties could be modified. Thus, the question is, how could such modifications affect microplastic effects on the plant–soil system?

Lozano et al. (2023) approached this question by simulating photodegradation of plastic fragments due to exposure to UV radiation and testing how the effects of different microplastics on soil properties and the performance of the plant *Daucus carota* differed between pristine and photodegraded plastics. In addition to previous studies that focused on assessing the effects of pristine plastics, this study considers that plastic waste remains in the environment for a long time. During this time, the plastic fragments are exposed to various factors promoting their degradation. However, previous studies did not address possible ecological implications of such degradation processes. To do so, Lozano et al. (2023) exposed microplastics representing different shapes (fibres, foams and films) and polymer types (PA, PET, PP, LDPE, PET, PS and PU) to UV-C degradation and subsequently grew individuals of *D. carota* in soil either containing pristine or photodegraded microplastics, or no added particles. Depending on the microplastic type, they found that photodegradation changed both physical and chemical properties by increasing brittleness, surface microcracks and roughness, inducing the formation of oxygenated groups and altering the water-absorption capacity of the microplastics. Degradation effects were also observed regarding soil properties. For example, degraded fibres increased soil respiration and degraded foams reduced soil aggregation compared to their pristine counterparts. Altered properties

of microplastics due to photodegradation also affected plant performance with degraded fibres and foams leading to a stronger increase of shoot and root biomass compared to pristine fragments, probably via cascading effects due to changed soil properties such as increased soil respiration or decreased soil aggregation. In contrast, the effects of microplastics on root morphology of the plants were not affected by photodegradation.

Overall, the study shows that modifications of microplastics' physical and chemical properties due to weathering, such as an altered surface structure or increased hydrophilicity due to the formation of carbonyl and hydroxyl groups, can cause cascading effects that can alter how microplastics affect soil properties and plant performance. In their study, however, the authors focus on just one species, *D. carota*, limiting the generalisability of the results. As previous studies have shown that microplastic effects on plants can be species specific, broadening the scope by including different species or by looking at potential effects on plant communities, in which the different species can interact with each other, would be an important next step to better assess potential effects microplastics might have in natural systems. Species specific responses, both in soil microbial communities and plant communities, for example by facilitating certain species while hampering others would have important implications for the community structure and could lead to further cascading effects. In this context, the observation that photodegradation can strengthen the effects microplastics have on soil properties and plant performance emphasises the need to better investigate such potential consequences as effects might be more pronounced under natural conditions due to chemical and physical modifications. Although these modification effects, as microplastic

effects in general, appear to be highly dependent on plastic characteristics such as polymer type and particle shape, the findings provide a proof of principle that aging can modify ecological effects of microplastics.

We should keep in mind that there is a continuous flow of plastic waste entering the environment and that it is highly unlikely that this flow will run dry in the foreseeable future. Consequently, more and more plastic waste, new and old, will accumulate in both aquatic and terrestrial ecosystems, and it will be there for quite a while. As, ultimately, we depend on the functioning of these ecosystems, next to taking inevitable steps to minimise the amount of plastic waste, we should be interested in how organisms and ecosystems are affected by this global and long-term issue. Recent studies have started to address this issue, but many questions remain to be answered. How does microplastic pollution affect higher organisational levels, for example plant communities? How does microplastic pollution interact with other global change factors such as eutrophication, increasing temperature or altered precipitation patterns? Could microplastic effects change over time? Regarding the latter question, the study by Lozano et al. (2023) provides first evidence that this is likely to be the case.

AUTHOR CONTRIBUTIONS

The manuscript was written by Benedikt Speier.

CONFLICT OF INTEREST STATEMENT

The author declares no conflict of interest.

DATA AVAILABILITY STATEMENT

No data were generated or used for this publication.

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